UW-SSEC/UMd Study Introduction: CLARREO Approach Perspectives

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UW-SSEC CLARREO Studies

- **Climate Product Evaluation using AIRS and IASI Data Sets** [Bob Knuteson]
- **Augmented Climate Product Orbital Sampling Study** [Dan Kirk-Davidoff, presented by Dave Tobin]
- **Cross-Calibration Accuracy Evaluation using Aqua & Metop-A Data Sets** [Dave Tobin, Bob Holz]
- **CLARREO Payload Requirements and Systems Design** [Fred Best, Joe Taylor]
  {Fred will also report on our IIP Plans tomorrow}

Background

- General principles and candidate flow-down requirements have been established for CLARREO as originally envisioned
- These have formed the basic foundation for our study tasks and our Instrument Incubator Program proposal with Harvard
- Brief summary here gives context to help focus discussion of points of agreement and any disagreements that can be investigated to establish the best approach

CLARREO: New Paradigms for Benchmark Climate Measurements

1) **High information content**, rather than just monitoring total radiative energy budget
(i.e. spectrally resolved radiances covering large parts of the spectrum as a product, rather than total IR or Solar fluxes—can separate IR & Solar obs.)

2) **Very high absolute accuracy, with measurement accuracy proven on orbit** (stability not sufficient)
   a) minimizes climate change detection time and
   b) relieves the need for mission overlap
(Must consider Total Accuracy = RSS of Spatial/ Temporal biases and measurement accuracy)

3) **Commitment to ongoing Benchmark Missions** planned with 5-8 year lifetime every 8-10 years
(Data for Model trend evaluation is needed for the foreseeable future, certainly the next century—therefore, affordability is a key ingredient)

CLARREO: Flow-down Corollaries

1) **<u>Primary products are direct observables, not derived fluxes or retrieved properties</u> (paradigms 1, 2)**
   [e.g. spectrally resolved, IR, nadir radiances (broadband, including far IR), averaged over regions and time of day to control spatial and temporal biases]

2) **<u>Minimize complexity</u> (paradigms 2-3)**
   (do one thing very well—e.g. no cross-track scanning, design for low biases, noise can be relatively high, keep non-linearity and polarization artifacts small)

CLARREO: Flow-down Corollaries (2)

3) **<u>Deploy an orbital configuration</u> <u>optimized for global coverage and to minimize sampling bias</u> (paradigm 2)**
   [e.g. equally spaced, truly polar orbits (90º inclination) giving global coverage and equal time of day sampling every 2 months—explicit diurnal cycle measurement]

4) **<u>Depend on other science and operational observations for process studies</u> (paradigm 3)**
   (Cross calibration improves the consistency and value for process studies. However, radiance observations from other sensors do not have the spectral coverage or absolute accuracy to be relied on for providing a fundamental component of the benchmark product)

CLARREO General IR Science Drivers

- **Information Content:** Capture the spectral signatures of regional and seasonal climate change that can be associated with physical climate forcing and response mechanisms (to unequivocally detect change and refine climate models)
- **Absolute Accuracy:** <0.1 K 2-sigma brightness T for combined measurement and sampling uncertainty (each <0.1 K 3-sigma) for annual averages of 15ºx30º lat/long regions (to approach goal of resolving a climate change signal in the decadal time frame)
- **Calibration transfer to other spaceborne IR sensors:** Accuracy approaching the measurement accuracy of CLARREO using Simultaneous Nadir Overpasses (to enhance value of sounders for climate process studies-actually drives few requirements)

Flow-Down IR Requirements (1)

- **Spectral Coverage:** 3-50 μm or 200-3000 cm^{-1} (includes Far IR to capture most of the information content and emitted energy)
- **Spectral Resolution:** ~0.5 cm^{-1} (1 cm max OPD) (to capture atmospheric stability, aid in achieving high radiometric accuracy, and allow accurate spectral calibration from atmospheric lines)
- **Spectral Sampling:** Nyquist sampled (to achieve standard spectral scale for multiple instruments)

Flow-Down IR Requirements (2)

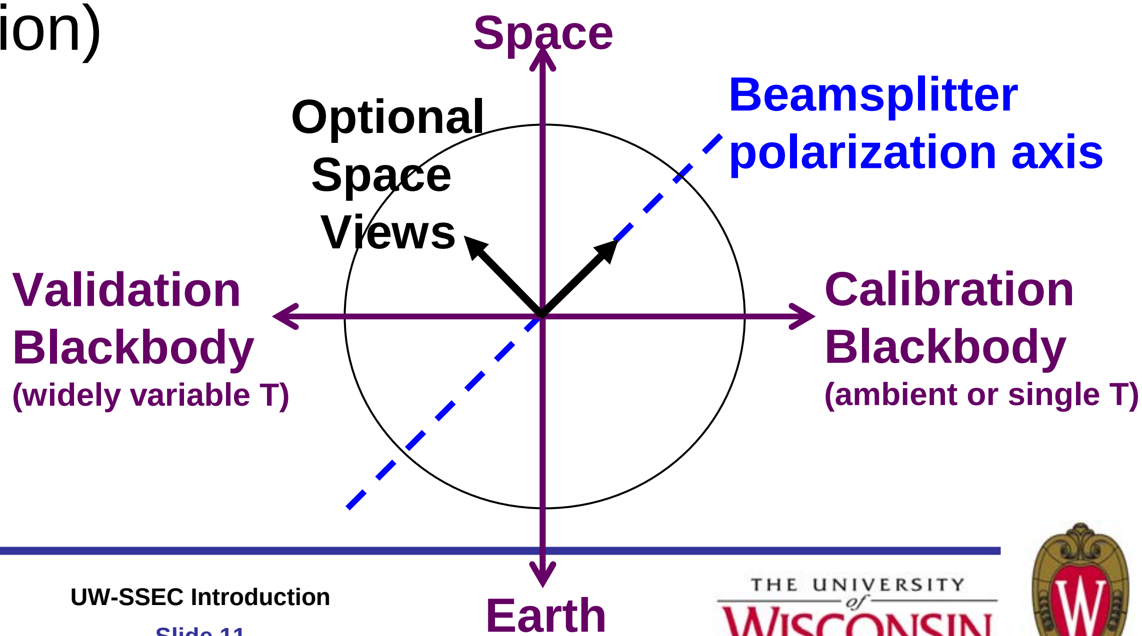
- **Spatial Footprint & Angular Sampling:**
  Order 100 km or less, nadir only
  (no strong sensitivity to footprint size, nadir only captures information content)
- **Spatial Coverage:** Complete global sampling
  (to not miss critical high latitude regions)
- **Orbits:** 3 90º inclination orbits spaced 60º apart
  (to minimize sampling biases that RSS with measurement uncertainty)
- **Temporal Resolution and Sampling:**
  < 15 sec resolution and < 15 sec intervals
  (adequate to reduce sampling errors and noise)

Flow-Down IR Requirements (3)

- **Spectrometer Approach:** 2 Fourier Transform Spectrometers
  (dual FTS sensors to detect unexpected drifts and give full spectral coverage with noise performance needed for calibration transfer and on-orbit characterization testing)
- **Noise:** NEdT(10 sec) < 1.5 K for climate record,
  < 1.3 K for cal transfer
  (not very demanding)
- **Detectors:** Pyroelectric for one FTS and cryogenic PV MCT and/or InSb for the other

Flow-Down IR Requirements (4)

- **On-orbit characterization:** provide non-linearity and polarization test capability
  - Non-linearity from Out-of-band Harmonics and variable temperature blackbody
  - Polarization from multiple space view directions (design also minimizes effects of gold scene mirror induced polarization)



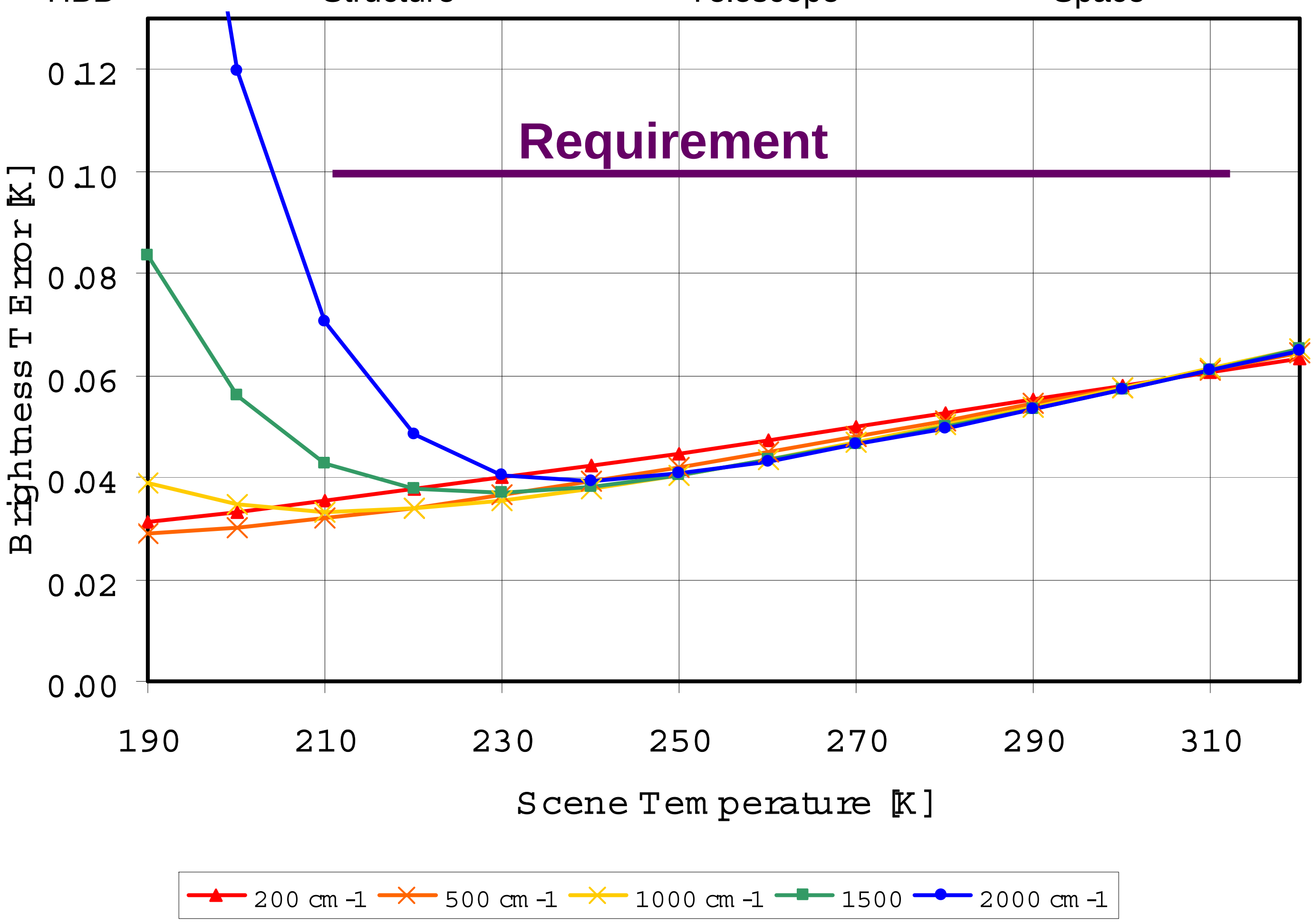
Flow-Down IR Requirements (5)

- **Pre-launch Calibration/Validation:** Characterization against NIST primary infrared standards and evaluation of flight blackbodies with NIST facilities
(recent "best practice")
- **On-orbit Calibration:**
Onboard warm blackbody reference (~300K), with phase change temperature calibration, plus space view, supplemented with characterization testing
(to detect any slow changes)
- **Validation, On-orbit:**
Variable-temperature Standard Blackbody, with on-orbit absolute T calibration and reflectivity measurement
(to maintain SI measurements on orbit)

CLARREO Expected Calibration Uncertainty:

Based on GIFTS Spaceflight Calibration Blackbody Design

T_{HBB}=300K, $T_{Structure}$=285K, $\delta T_{Telescope}$=0.02K, ε_{Space} =0.00010



Separate SI Validation Standard Blackbody

- Provides capability to validate or correct SI measurement on-orbit
  - New On-orbit Temperature Calibration technique is based on fundamental phase change principles
  - Normal Reflectivity/Emissivity is measured on-orbit